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An Annotated Bibliography on Science Education and the Visually Handicapped

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An Annotated Bibliography
on
Science Education
and the
Visually Handicapped

Purpose

Visually handicapped science students are presently entering the public school system in ever increasing proportions, often presenting special educational problems for the science teacher who has had little or no experience in instructing the visually handicapped. Currently, no comprehensive list exists of published literature related to science education and the visually impaired. Such a list, provided in the form of an annotated bibliography, would provide science educators and science materials developers with references of methods, materials, and research specific to individual topics under the broad heading of science education; e.g. basic laboratory experiments in dissection for the blind biology student. It is the purpose of this study to prepare a review of twentieth century literature related to science education and the visually handicapped student in the format of an annotated bibliography.

Procedure

Literature cited in partial bibliographies and cross-references from sources such as the National Science Teachers Association, the American Foundation for the Blind, the American Printing House for the Blind, the American Association of Instructors of the Blind, ERIC Document Service, Dissertation Abstracts International, and Science for the Handicapped Association was reviewed and abstracted. Of the 215 entries in this bibliography, journal abstracts were available for 59 or 27.5% of the articles. Only nine of the 215 entries were regionally unavailable for review and these nine sources are included in Section III of this bibliography as potentially useful information.

During the development of this bibliography, similar annotated bibliographies for all handicaps other than vision impairment were being prepared by Maria Egbert, National Technical Institute for the Deaf, and Kenneth Ricker, University of Georgia. In Fall 1980, all these works will be contained in a book to be published by the Educational Resources Information Center (ERIC) under the title: Science for the Handicapped: An Annotated Bibliography, by Marie Egbert, Robert Glass, and Kenneth Ricker; Benjamin Thompson, editor. Copies can be obtained from ERIC, P.O. Box 190, Arlington, Virginia, 22210.

I. Research Supported by Data

Boldt, Werner. "The Development of Scientific Thinking in Blind Children and Adolescents." Education of the Visually Handicapped, Vol. 1, No. 1, pp. 5-8, March, 1969. EJ 010 797.

The development of the concept formation of scientific and technical phenomena was researched empirically in order to clarify the pedagogical-psychological presupposition of teaching science to the blind. The study gives an informative view into the way in which blind pupils theorize. Basic forms of scientific thinking in their specificity and in their effect for the development of an "objective" understanding of the environment are considered.

Brekke, Beverly, John D. Williams and Perla Tait. "The Acquisition of Conservation of Weight by Visually Impaired Children." Journal of Genetic Psychology, Vol. 125, No. 5, pp. 89-97, May, 1974.

A modification of Furth's conservation of weight problems was administered to 72 legally blind children 6-14 years of age; 46 of the Ss resided in institutions for the blind, and 26 Ss lived in a family situation. A control group of sighted children matched for age was also tested. There were no differences in conservation between the blind group living at home and the sighted group. Both the sighted group and the blind group living at home conserved more often than the institutionalized blind Ss ($p < .05$). Further investigations of the differences between the two groups of blind Ss showed that degree of blindness was of lesser importance than place of residence.

Franks, Frank L. "Measurement in Science and Blind Students." Teaching Exceptional Children, Vol. 3, No. 1, pp. 2-11, Fall, 1970. EJ 029 875.

Instruments necessary to teach measurement operations and basic properties of matter were identified. As a result, a thermometer, a ruler in inches and centimeters, and a spring and a pan balance were adapted for tactual inspection by blind students. In the study 86% of the measurements and simple experiments were successfully performed by 51 junior high and 19 elementary school students using the aids.

Franks, Frank L. "Introduction to Map Study: Teaching Locational and Directional Referents to Young Blind Students." Doctoral dissertation, George Peabody College for Teachers, 1974.

Three maps which sequentially introduced areal, linear, and point symbols were developed. The format facilitated the interrelation of fundamental map reading concepts with the classroom, the school environment, and with natural and cultural features within the community. Eighty legally blind students (grades K-6) were used in the study. Computations using the Kuder-Richardson Formula 20 to determine consistency of the pretest and

the posttest revealed a reliability of .95 for the pretest and a reliability of .95 for the posttest. Significant gains in learning beyond the .01 level of significance were reported for 26 of the 30 concepts taught in the program. The small increase in learning on the four remaining items is attributed to prior knowledge.

Franks, Frank L. and Richard M. Baird. "Geographical Concepts and the Visually Handicapped." Exceptional Children, Vol. 38, No. 4, pp. 321-324, December, 1971.

The results of this study indicate that the series of three-dimensional raised surface landforms reported provide highly discriminable illustrations of 40 basic geographical terms for use by visually handicapped students. The system of tactile and chromatic coding which was developed provides easily discriminable cues and surface areas, even for some braille readers with extremely limited residual vision. Overall percentage of correct identification of the features illustrated on the landforms was 83.5%.

Franks, Frank L. and Lawrence H. Butterfield, Jr. "Educational Materials Development in Primary Science: Simple Machines." Education of the Visually Handicapped, Vol. 9, No. 1, pp. 51-55, Summer, 1977.

The study evaluated the ability of 27 legally blind students from the elementary grades (ages 7-13) to identify and manipulate the parts of the lever, the inclined plane, the wheel and axle, and the pulley. Performance scores exceeded 90% correct responses on each machine.

Franks, Frank L. and Roger Huff. "Educational Materials Development in Primary Science: Dial Thermometer Instructional Unit." Education of the Visually Handicapped, Vol. 8, No. 4, pp. 120-124, Winter, 1976-1977.

The results of this study indicate that the majority of 61 legally blind subjects (grades 2-4) were able to locate and recognize the point, areal, and linear symbols tested on the dial thermometer schematic, to locate specific lines, and to locate specified point and linear symbols using a pointer as set by the examiner. One hundred percent of the subjects located and recognized four distinctive features on the dial thermometer schematic: any raised line, the raised circle, the raised rough surface, and the pointer.

Franks, Frank L. and Roger Huff. "Educational Materials Development in Primary Science: The Pull-Apart Cell." Education of the Visually Handicapped, Vol. 8, No. 1, pp. 16-20, Spring, 1976. EJ 139 448.

The study evaluated the ability of 61 visually handicapped students (grades 2-4) to discriminate textures and to utilize them in locating and identifying the layers on a pull-apart cell model (schematic). The study also

evaluated the ability of students to manipulate the pull-apart features of the cell model. As a group the students scored well above the chance level on discrimination and identification-location tasks. Ninety-seven percent of the subjects were able to identify all discriminations correctly. The results confirm that young visually handicapped students in this study were able to perform the discrimination and identification-location tasks necessary for learning the parts of a simple plant and animal cell with pull-apart features.

Franks, Frank L. and Roger Huff. "Educational Materials Development in Primary Science: Insect Identification Kit." Education of the Visually Handicapped. Vol. 8, No. 2, pp. 57-62, Summer, 1976. EJ 146 616.

The primary purpose of this study was to determine if 71 young visually handicapped students (grades 2-4) could learn to identify the basic body parts of an insect on a three-dimensional model (schematic) using a set of training materials. The combined performance scores for braille and large print students using the insect models ranged from 91% to 100%. The complete kit contains a set of five models.

Franks, Frank L. and Roger Huff. "Educational Materials Development in Primary Science: Linear Measurement for Young Blind Students." Education of the Visually Handicapped, Vol. 9, No. 1, pp. 23-28, Spring, 1977.

A tactile ruler instructional unit was evaluated using 37 legally blind students (grades 2-4). Tasks in counting inch and centimeter lines exceeded the criterion of 80% correct responses.

Franks, Frank L. and Marvin J. Murr. "Biological Models for Blind Students." Journal of Visual Impairment and Blindness, Vol. 72, No. 4, pp. 121-124, April, 1978.

In response to an expressed need for inexpensive biological models for blind students, the American Printing House for the Blind has developed a set of 19 plastic models (schematics) which illustrate representative species of the major invertebrate phyla and component structures of flowering plants. The biological features depicted on the models were found to be highly discriminable in a test of legibility (95% overall correct responses) with 42 legally blind students (grades 7-12). The models emphasize simplicity, but offer additional cues where complexity occurs. Texture, size, shape, and relief were used for maximum legibility. Chromatic color coding was employed to maximize color and luminance contrasts for low vision students. The models average nine inches (22.9 cm) in length on their longest sides.

Franks, Frank L. and Carson Y. Nolan. "Measuring Geographical Concept Attainment in Visually Handicapped Students." Education of the Visually Handicapped, Vol. 3, No. 1, pp. 11-17, March, 1971.

A forty-item test measuring geographical concept attainment of visually handicapped students was developed which allowed students to record their own responses. A comparison of performance scores of braille readers and large print readers indicates that the pattern of performance for these groups tested on the short-form test (40 items) is comparable to the pattern of performance of braille students tested on the longer individual test (70 items). No significant differences were found between braille readers and large print readers on the 40-item test. A practical application of the 40-item test verified its reliability with the population tested as an instrument for evaluating geographical concept attainment of visually handicapped students in educational programs.

Gough, Elva Ruth. "The Science-Related Problem-Solving Processes of Visually Impaired Adolescents." Dissertation Abstracts International, Vol. 38, No. 6, p. 3399A, June, 1977.

The purposes of this descriptive study were to: (1) identify the processes employed by individual visually impaired secondary students to solve multiple-choice biology problems and essay environmental problems, (2) determine whether there was a difference in the solution processes used to attain correct solutions and incorrect solutions, and (3) determine if a difference existed between the processes employed to solve multiple-choice biology problems and those used to solve essay environmental problems. Tape recorded protocols of thought processes verbalized by nine legally blind Ss as they solved the various problems were analyzed using a classification code designed for this study. Differences significant at the .05 level of confidence were identified in individual solution processes.

Linn, Marcia C. "An Experiential Science Curriculum for the Visually Impaired." Exceptional Children, Vol. 39, No. 1, pp. 37-43, September, 1972. EJ 063 359.

Adaptation and evaluation of a materials centered experiential curriculum for elementary age visually impaired children is described. The adaptations of both the physical and the life sciences units can be used in classes with one or two visually impaired students and in classes of all visually impaired students. Evaluation measures were designed to assess the major objectives of each unit. Classroom trials of two of the adapted units revealed that visually impaired students made significant gains in understanding both content and process objectives of the units.

Linn, Marcia C. "Adapting Science Materials for the Blind (ASMB): the Development of Logical Thinking." Paper presented at meeting of the Association for Education of the Visually Handicapped, June, 1974, San Francisco, California. 11 p.

A description is given of the Science Curriculum Improvement Study (SCIS) program and the adaptations developed by Adapting Science Materials for the Blind (ASMB). Characteristics of the logical development of the

visually impaired child are discussed, the aspects of ASMB that foster logical thought are delineated, and some research on ASMB and logical thought is presented that replicated and extended a study by Linn and Peterson (1973). Results obtained from 117 legally blind, first-grade pupils revealed that all Ss who studied Material Objects exceeded controls in logical thinking skills. Results for visually impaired and culturally diverse paralleled those of Linn and Peterson (1973). For middle-class Ss, Linn and Peterson found no gains, while the replication study revealed that their logical thinking skill increased.

Linn, Marcia C. and Rita W. Peterson. "The Effect of Direct Experience with Objects on Middle Class, Culturally Diverse, and Visually Impaired Children." Journal of Research in Science Teaching, Vol. 10, No. 1, pp. 83-90, January, 1973.

Piaget's theory of equilibration is investigated by comparing the effect of direct experience with objects on the logical reasoning ability of middle class (MC), culturally diverse (CD), and visually impaired (VI) children. In experiment I a Piagetian task with floating and sinking objects was used to compare the classificatory ability of MC, CD, and VI groups studying SCIS Material Objects with those who had not studied the unit. Experimental CD and VI Ss performed significantly better on the task than controls; no significant differences were found between MC experimentals and controls. MC groups performed better than CD and VI groups in both experimental and control conditions.

Experiment II measured Ss' ability to name properties and materials and to sort objects. Both MC and VI Ss improved in ability to describe objects and sort them using a descriptor of their own choice. There were no differences between MC and VI Ss on these tasks after they had studied Material Objects.

Linn, Marcia C. and Herbert D. Their. "Adapting Science Material for the Blind (ASMB): Expectation for Student Outcome." Science Education, Vol. 59, No. 2, pp. 237-246, Spring, 1975. EJ 121 548.

This study reports an investigation concerning whether additional concrete experiences with objects will foster the logical development of blind children. The success of the Adapting Science Materials for the Blind (ASMB) units for various goals and various learner groups are discussed and tentative conclusions drawn. Significant gains were made.

Long, Nancy Thurston. "Science Curriculum Improvement Study (SCIS): Its Effect on Concept Development and Manipulative Skills in Visually Handicapped Children." Dissertation Abstracts International, Vol. 34, No. 4, pp. 1738A-1739A, April, 1973. (University Microfilms No. 73-21, 621). ED 094 963.

This study examined the effectiveness of the Science Curriculum Improvement Study (SCIS) materials for visually handicapped children. Fourteen students, ranging in age from 9 to 19 and working in small groups with

student teachers, received science instruction using the adapted version of the SCIS program. Control subjects were matched closely on age, medium of reading, socioeconomic status, and additional handicaps. These children participated as usual in the science program offered at their schools. Both groups were tested in the Fall and in the following Spring. Post-test data showed a superior performance by the experimental group over the control group on the three tests, "Histograms," "System and Interaction," and "Science and Learning," significant beyond the .05 level.

Mallinson, George G. Programmed Learning Materials for the Blind. Kalamazoo, Mich.: Western Michigan University, 85 p., March, 1967. (Contract No. OEC-7-32-0580-191). ED 014 193.

In this research study, tests determined that the most efficient braille stimulus-braille response format was a booklet in which the braille frame appeared on one page and the correct response on the next. Commercially available programs for junior high school science were modified for use with blind students in accordance with the study findings. Two 50 frame programs reproduced in braille were tested with 57 blind junior high school students. Results indicated that students could handle these programmed materials in a reasonable amount of time with a high degree of accuracy. Instructions were followed with minimal difficulty. Performance improved with the second book. In modifying the program for use with the blind, 32 symbols were developed for the most frequently used science terms in order to reduce the bulk of braille materials. To determine whether blind students could discriminate among the symbols and between the symbols and braille, 43 blind students (grades 6-10) were given tests containing the various science symbols. Scores improved with increasing IQ and grade levels through junior high, although high school students reacted poorly. Scores and times improved with a second trial. Appendices contain simple science programs on "Physical and Chemical Change," "Symbols and Formulae," and "Plastids."

Mallinson, George G. and Jacqueline V. Mallinson. "Symbolic Science Learning for the Blind." School Science and Mathematics, Vol. 67, No. 5, pp. 432-449, May, 1967. ED 012 238.

Discussed is the development and testing of braille-type science symbols for blind secondary school science students. A review of secondary science textbooks, state science syllabuses, courses of study, and vocabulary lists was used to identify 50 important recurring science terms. The terms were submitted for evaluation to university scientists, science educators, and specialists in the teaching of blind children. Meaningful symbols were developed for 32 of the terms, and symbol revisions were made on the basis of a pilot test with blind children. Results indicated that average students had little difficulty distinguishing between different science symbols and between science symbols and braille symbols. Intelligence and emotional stability were significantly related to student performance. Test performance generally improved with practice.

Merry, Frieda K. "A Study of the Merits of Animal Models Used in Teaching Blind Children." Teachers' Forum, Vol. 2, p. 12, 1930.

In three studies to determine the usefulness of animal models in teaching blind students, conclusions supported the need for beginning nature study with young blind students, the superiority of three-dimensional models over two-dimensional representations of three-dimensional objects, and the necessity of much care in selecting animal specimens for use with blind students.

Nolan, Carson Y. and June E. Morris. "The Japanese Abacus as a Computational Aid for the Blind." Exceptional Children, Vol. 31, No. 1, pp. 15-17, September, 1964.

Forty-two junior high level students were instructed in the use of the soroban, a type of abacus. Prior to instruction, the students were tested with an easy test and a difficult test to determine their skill in computation of whole and decimal numbers. After four months and again after eight months of instruction and practice with the soroban, the students were tested with equivalent tests. The results demonstrated that the soroban is a practical and efficient approach for overcoming computational problems encountered by the blind.

Struve, Nancy L., Herbert D. Their, Doris E. Hadary, and Marcia C. Linn. "The Effect of an Experiential Science Curriculum for the Visually Impaired on Course Objectives and Manipulative Skills." Education of the Visually Handicapped, Vol. 7, No. 1, pp. 9-14, March, 1975. EJ 120 854.

This study was conducted with 30 visually handicapped students to determine what effect the learning experiences of the Science Curriculum Improvement Study (SCIS) had on the manipulative skills of the upper-elementary aged visually impaired child. In addition, the study was designed to investigate the relationship between improved manipulative skills and progress on the content, process, and logical thinking objectives of the adapted SCIS program. Improvement in many manipulative skills such as pouring, filtering, and organizing objects was found.

Struve, Nancy L., Herbert D. Their, Doris E. Hadary, and Marcia C. Linn. "Materials Centered Science and Manipulative Skill." Exceptional Children, Vol. 40, No. 7, pp. 516-517, April, 1974. EJ 099 467.

Evaluated were effects of experience with two physical science units adapted for use by the visually impaired on the manipulative skills of 14 visually impaired low income students from 9 to 19 years of age.

Tobin, M. J., D. Clark, I. Lane, and V. G. Pittam. "Programmed Learning for the Blind: Some Exploratory Studies." Education of the Visually Handicapped, Vol. 2, No. 1, pp. 11-23, March, 1970. EJ 017 389.

Two studies from this broad collection of studies are related to the application of programmed audio instruction to lessons on electricity. The aim was to introduce some of the concepts at an elementary level and to engage the pupil in a variety of experiments illustrating the phenomena of static electricity by means of programmed instruction. Results suggest that a significant amount of learning can be achieved using group methods of programmed audio presentation that allow the teacher to retain control over the pace of learning.

II. General Publication

Akey, John M. "An Audiovisual Presentation for Non-Audiovisual Students." Science Teacher, Vol. 41, No. 9, pp. 52-53, December, 1974. EJ 109 936.

This study describes how a planetarium demonstration can be adapted for blind students and deaf students.

Allen, Edward E. "Opening Windows on Nature for Blind Boys and Girls." School Life, Vol. 17, No. 2, pp. 21-22, 31, October, 1931.

The program of nature study at the Perkins School for the Blind is presented. Stuffed animals, actual specimens, and models are used and the variety of plant life on the school's 34 acre campus is described. Students are encouraged to care for livestock owned by the school.

American Association of Instructors of the Blind. General Science: A One Year Course of Study Adapted for Use in Schools for the Blind. New York: American Foundation for the Blind, 27 p., 1933.

Reported is a complete course of general science study prepared by the General Science Committee of the American Association of Instructors of the Blind.

American Foundation for the Blind. An Introduction to the Development of Curriculum for Educable Mentally Retarded Visually Handicapped Adolescents. New York: American Foundation for the Blind, 46 p., 1968. ED 026 785.

Suggestions for curriculum development for educable mentally handicapped, visually impaired students between the ages of 13 and 18 years are presented. A discussion of communication skills includes the areas of listening, oral communication, reading, writing, and spelling and teaching methods for each. The goals of the computation skills sequence, basic understanding of mathematical concepts, and transfer of knowledge to other situations are discussed along with skills to be taught. A comprehensive secondary school curriculum is described which includes specific recommendations for the teaching of science courses.

American Foundation for the Blind. Products for People with Vision Problems: Twenty-Fifth Anniversary Edition. New York: American Foundation for the Blind, 162 p., Fall, 1979.

This catalog contains over 400 products useful to the visually impaired. Devices applicable to science instruction and the blind include: brailled stopwatches, timers, game equipment, barometers, thermometers, compasses, talking thermometers and calculators, magnifiers, writing aids, slide rules, protractors, compasses, rulers, micrometers, audible multimeters, and scales.

American Printing House for the Blind. Educational Aids for the Visually Handicapped. Louisville, Ky.: American Printing House for the Blind, 27 p., February, 1969. ED 030 242.

Listings specifying sources and costs of tactile aids and materials designed for the visually handicapped are provided. Items are presented in the following categories: supply sources and catalogs for aids, braille devices, including duplicators, reading and writing aids, reading readiness materials, writing machines, slates and styluses, deaf-blind aids, electronic devices, games, mobility aids, optical aids for instruments, paper and binders, personal aids, preschool devices and materials, recording and sound equipment. Additional categories of listings are in the subject areas of geography and social studies, handwriting and typewriting, health education, language arts, mathematics (general, counting, geometric, linear measurement, slates, and time), music, physical education, practical arts (cooking and sewing), science, and vocational education (industrial arts).

American Printing House for the Blind. The Central Catalog: Instructional Materials Reference Center. Louisville, Ky.: American Printing House for the Blind, 771 p., 1968. (Grant No. OEG-2-6062289-1582). ED 035 114.

Intended as a source of information for the benefit of transcribers, school administrators, teachers, librarians, students, parents, and all workers for the blind, the catalog contains an alphabetical listing, by subject area, of completed titles of books listed in the central catalog of volunteer produced braille, large type, and recorded textbooks. Commercially produced large type textbooks and supplementary reading materials are also cited. Although the catalog cannot be supplied to individuals, copies are available at all residential schools for the blind, state departments of education, instructional materials centers, major volunteer transcriber groups, agencies for the education of the visually handicapped, and commercial producers of large type. Supplements are issued periodically.

Andrews, Francis M., Jr. "The Biology Laboratory Period." Teachers Forum, Vol. 6, No. 5, pp. 82-83, May, 1934.

Discussed are methods and materials for conducting high school biology laboratory exercises involving the dissection of insects, earthworms, clams, starfish, fish, frogs, snakes, and hens. The use of preserved or freshly killed specimens is preferred over the use of models.

Ballard, Byron, B. "The Physical Sciences in the Junior High School." American Association of Instructors of the Blind, Thirty-fourth Biennial Convention, pp. 188-190, June, 1938.

The special advantages derived from teaching physical science and biology in schools for the blind are discussed as they relate to increasing the blind child's awareness and understanding of the environment. Difficulties

to overcome are addressed and the suggestion is made that schools offer one kind of instruction for college bound science students and a different, lay-oriented instruction for other students who need to know practical applications of science to daily life.

Baughman, James and Dean Zollman. "Physics Labs for the Blind." Physics Teacher, Vol. 15, No. 6, pp. 339-342, September, 1977. EJ 166 575.

This study describes laboratory equipment which has been modified to accommodate visually handicapped students enrolled in regular university level laboratory science courses.

Bechthold, E. "Die Naturbeobachtung des Schülers in der Blindenschule." Blindenfreund, Vol. 40, pp. 157-164, 1920.

Suggestions for making the teaching of exact sciences in schools for the blind alive, understandable, and related to the daily experience of the student are presented. Included in the paper is a list of problems assigned to upper class students during the years 1916-1917.

Benham, Thomas A. "Aids for the Blind." Electrical Engineering, Vol. 66, No. 2, pp. 178-182, February, 1947.

Reported are several practical instruments developed by the author, a blind electronic engineer, to facilitate the performance of various kinds of electrical measurements by blind persons.

Benham, Thomas A. "Science for the Blind." American Journal of Physics, Vol. 23, No. 3, pp. 177-178, March, 1955.

This article proposes that recorded versions of scientific textbooks and journals be made available to the visually handicapped. Suggestions and ideas are solicited for lists of materials to record, possible recording sites, and sources of funding. The writer is a blind physics teacher of sighted students.

Benham, Thomas A. "Science for the Blind." American Journal of Physics, Vol. 24, No. 1, p. 45, January, 1956.

This article reports the findings of a proposal to begin recording science textbooks and journals for international distribution to the visually handicapped. Institutional support for the effort came from Science for the Blind, a department of the Pennsylvania Association for the Blind. Subscriptions are solicited.

Benham, Thomas A., John Dupress, Clifford Witcher, Kathern Gruber, and Arthur Helms. Recording Science Texts for the Blind. New York: American Foundation for the Blind, 40 p., July, 1957.

The procedures and suggestions which appear in this publication were made possible largely through the direct experience of Dr. Benham in his actual recording of scientific material for Science for the Blind. The contents include reader qualifications, editing, explanation of graphic material, reading equations and formulas, reading footnotes and references, recording tables of contents, spelling, making braille diagrams, securing permission to record, and putting graphs, diagrams, and structural formulas into words.

Bluhm, Donna L. Teaching the Retarded Visually Handicapped: Indeed They Are Children. Philadelphia: W. B. Saunders Co., 127 p., October, 1978.
ED 026 773.

Guidelines for a program of instruction with individual teaching for retarded blind children are provided. Areas covered are living skills, handwork, learning through music, reading readiness, recognition of the braille alphabet, mathematics, science, social studies, self expression, creativity, recreation, and suggested poetry and songs. Five appendices discuss regional educational centers for the blind, parent-child relations, adjustment problems, learning from and teaching the children. Photographs of 19 teaching aids are provided.

Botts, J. H. "Our New Course in General Science." American Association of Instructors of the Blind, Thirty-second Biennial Convention, pp. 127-131, June, 1934.

Current materials and laboratory exercises for the general science teacher in residential schools for the blind are discussed. Principles considered essential to the successful teaching of general science are described.

Botts, J. H. "What Features Should be Considered in Selecting a Text in Biology for the Blind." American Association of Instructors of the Blind, Thirty-fifth Biennial Convention, pp. 161-166, June, 1940.

Current topics in biology are presented as guidelines for text selection. Preferred are textbooks which include Darwinian Theory and Medelian Law, hereditary aspects of blindness, sex hygiene, and personal hygiene, as well as the study of plants and animals.

Branch, Hazel E. "That the Blind May See." American Biology Teacher, Vol. 5, No. 1, pp. 34-36, October, 1942.

Described are methods of making illustrations, diagrams, and models understandable to a blind student of biology.

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Brooks, G. W. "Biology for the Blind Student." The Teaching of Science and Mathematics to the Blind (with section on Raised Diagrams): Report to the Viscount Nuffield Auxiliary Fund, ed. R. Fletcher, London: Royal National Institute for the Blind, pp. 33-34, 1973.

A secondary school biology program which emphasizes human anatomy, hygiene, physiology, and the use of live and preserved specimens is described.

Brown, Dean R. "Science Instruction of Visually Impaired Youth: A Research and Review of Relevant Literature." American Foundation for the Blind: Practice Report Series, 20 p., 1979.

This report is a review of the literature on teaching science to visually impaired students at elementary, secondary, and higher education levels, and emphasizes how science concepts are learned. The report also discusses adaptation and modification of materials and equipment, and views the pairing of visually impaired students with sighted peers as the key to teaching science.

Bryan, Arthur H. "Biology for Blind Students." Teachers Forum, Vol. 4, No. 3, pp. 42-47, January, 1932.

The special projects, problems, and methods encountered in teaching biology to the blind are discussed. Clay models used in biological and botanical microscopy are described. Methods are presented for teaching topics such as yeasts, molds, mushrooms, mosses, ferns, sponges, corals, starfish, worms, insects, crayfish, snails, clams, fish, frogs, birds, and rodents. Sighted laboratory partners and the use of actual specimens are integral to the methods given.

Bryan, Arthur H. "Science for the Blind." Baltimore Bulletin of Education, Vol. 19, No. 1, p. 47, September, 1941.

This article describes the activities of and methods used by blind students enrolled in regular classes in physics, biology, and chemistry at Baltimore City College. The results of permitting the visually handicapped to enroll in these previously closed classes is the central theme.

Bryan, Arthur H. "Methods of Teaching Biology to Blind Students with the Seeing." American Biology Teacher, Vol. 12, No. 4, pp. 75-81, April, 1950.

Discussed are the problems of the blind student in college level biology classes. Recommendations are made for a multi-sensory approach, the use of instructor made clay models when possible, and vocational guidance. Special emphasis is given to the teaching of morphological biology and the intimate study of skeletal forms, botany, and nature appreciation.

Bryan, Arthur H. "Sciences for the Blind." Baltimore Bulletin of Education, Vol. 29, No. 1, pp. 14-15, September, 1951.

Several methods and materials for instructing the blind in biology, physics, chemistry, general science, zoology, and human physiology are briefly presented. Possible science hobbies and vocations are suggested.

Bryan, Arthur H. "Physics for the Blind." Science Education, Vol. 35, No. 12, pp. 271-274, December, 1951.

Teaching aspects related to the blind student enrolled in regular, secondary level physics classes are discussed. Suggestions are made for adapting laboratory exercises. The use of sighted lab partners is also encouraged.

Byran, Arthur H. "Chemistry for the Blind." Science Education, Vol. 36, No. 3, pp. 91-95, March, 1952.

Methods for adapting the high school chemistry curriculum, including laboratory exercises and teaching facilities, are described in this article. Major instructional objectives are also included.

Bryan, Arthur H. "General Science for the Blind." Science Education, Vol. 41, No. 2, pp. 26-30, February, 1957.

This article presents suggestions for the integration and instruction of the blind student enrolled in secondary level general science courses in public schools.

Bryan, Charles A. "Secondary School Sciences for the Blind." International Journal for the Education of the Blind, Vol. 6, No. 1, pp. 11-18, October, 1956.

It is the writer's thesis that the blind are entirely educable. Described are instructional objectives and alternative teaching strategies for visually impaired students in the secondary school sciences of biology, physics, and chemistry.

Bunner, William R. and Richard T. Bunner. "What About Your Visually Defective Students?" The American Biology Teacher, Vol. 30, No. 2, pp. 108-109. February, 1968.

The problems of teaching biology to the blind are discussed and practical suggestions for teaching the visually handicapped are offered. Partially sighted students are encouraged to dissect and work with the microscope and totally blind students are recommended as data recorders in laboratory exercises. Suggestions for making tactile schematics and models are provided and the use of the Sewell Raised Line Drawing Kit is described.

Burde, E. "Die Pflanzkunde in der blindenschule." Blindenfreund, Vol. 40, pp. 105-109, 1920.

The fundamental principles of teaching botany in schools for the blind are discussed. Included in the paper is a course of study of the subject for the year 1920 for the school for the blind in Silesia.

Burke, Emily A. "Laboratory Work in Science for the Blind." Teachers Forum, Vol. 4, No. 3, pp. 48-49, January, 1932.

This report describes how useful laboratory specimens are obtained from a local museum for use in science courses at the Western Pennsylvania School for the Blind. Through this arrangement, considerable expense to the school in accumulating exhibit material is avoided and the overall program in science instruction is greatly enhanced.

California School for the Blind Staff. "The Teaching of Nature Study." Teachers Forum, Vol. 2, No. 1, pp. 6-7, September, 1929.

A description is presented of methods and materials for teaching nature study in a residential school for the blind.

Carver, Thomas R. "The Design and Use of a Light Probe for Teaching Science to Blind Students." American Foundation for the Blind Research Bulletin, No. 16, pp. 79-91, May, 1968.

The evolution, design, and use of an optical light probe particularly suited to teaching laboratory science skills to blind students is described. A simple pocket-sized light probe with certain necessary features proved to be the missing link which enables blind students to do ordinary physics laboratory experiments.

Champion, Richard R. "The Talking Calculator Used with Blind Students." Education of the Visually Handicapped, Vol. 8, No. 4, pp. 102-106, Winter, 1976.

This study demonstrated that blind children in grades three through eight were able to achieve greater speed and accuracy in mathematical computations using the talking calculator after one hour of individualized instruction and three weeks of informal practice. Implications for modifications in operational procedures are also discussed. The APH Speech Plus Calculator is available from the American Printing House for the Blind, Louisville, Kentucky.

Charleston, Steward E. and others. "Training Blind and Visually Handicapped Computer Programmers." California State Department of Rehabilitation, Sacramento; System Development Corporation, Santa Monica, California, 7 p., July, 1976. ED 125 579.

The state of California and System Development Corporation have developed, implemented, and evaluated a training program in computer programming for the blind and visually impaired. Students are selected according to general aptitude, interests, general intelligence, previous educational achievement, health, and personal qualities. The eight-month course in programming involves 120 classroom hours per month. The curriculum is modular to allow flexibility in introducing new computer technology and languages as they become available. Students record lectures on tape recorders. Closed circuit television systems for low-vision students and the OPTACON for the totally blind are also used. Recorded and braille reference materials are also available to the students, and classroom handouts are reproduced on a braille duplicator. Student retention in the program and job placement and performance have been successful.

Chatfield, Alice. "Capitalizing the Value of Models to Meet the Demands of the Current Trend in Primary Education." American Association of Instructors of the Blind, Thirty-fifth Biennial Convention, pp. 52-54, June, 1940.

Discussed is the use of three-dimensional educational models in a school for the blind.

Cochran, Carolyn B. "Creating a Nature Interest in the Kindergarten." American Association of Instructors of the Blind, Thirty-ninth Biennial Convention, pp. 60-62, June, 1948.

Reported are simple efforts to create interest in nature study in kindergarten pupils. Described are visits to a dairy farm, a bakery, a vegetable garden, and special units that require active participation by the children.

Coon, Nelson. "The Relation of the Museum to Tactual Education." Teachers Forum, Vol. 14, No. 1, pp. 33-34, 39, September, 1941.

Reported are experiments carried out at Perkins Institution over a period of two years in making the museum collection a vital part of the school and in encouraging its regular and systematic use.

Cooper, Katherine E. and Herbert D. Their. "Do You Have to See it to Believe It: Laboratory Science for Visually Impaired Children." Learning, Vol. 2, No. 8, pp. 54-55, April, 1974.

The adaptation for the visually impaired of the Science Curriculum Improvement Study (SCIS) materials is reported. Concepts taught and materials included in the Adapting Science Materials for the Blind (ASMB) program are described. A representative lesson for fourth-grade students on relative position and motion is presented.

Coville, M. Genevieve. "Science Committee Notes: Laboratory Work." Teachers Forum, Vol. 4, No. 5, pp. 90, 93, May, 1932.

Principles governing progressive educational procedure are presented along with criteria for laboratory materials selection. A simple project involving root, stem, and leaf systems is presented.

Coville, M. Genevieve. "Content of a Course in General Science Adapted for Use with the Blind." American Association of Instructors of the Blind, Thirty-first Biennial Convention, pp. 773-775, July, 1932.

After careful consideration of the results of a national survey of general science curriculums in schools for the blind, a 14 unit plan of sequenced general science topics was recommended for teachers of the blind and a detailed outline of the content of each topic was formulated.

Cranmer, T. V. "Liquid Level Indicator for the Blind: Electronic Device." Popular Electronics, Vol. 26, No. 5, pp. 59-60, May, 1967.

A light sensitive, electronic device which has been found useful for determining the levels of fluids in transparent containers is described.

Cravats, Monroe. "Biology for the Blind." The Science Teacher, Vol. 39, No. 4, pp. 49-50, April, 1972.

For the visually impaired biology student, several laboratory exercises are presented which study the aspects of human digestion. No tactual models are required and materials used are simple and easily available.

Crockett, Myrtle C. "The Field Trip." International Journal for the Education of the Blind, Vol. 7, No. 4, pp. 136-137, May, 1958.

The value of the field trip as a teaching procedure for blind students is discussed. Several checklists are provided to aid the teacher in preliminary preparation, classroom preparation, and trip evaluation. Important points to remember and causes of difficulties are also listed.

Cuthbertson, N. D. "Blind Nature Study." Teacher of the Blind, Vol. 17, pp. 188-194, 213-218, 1929.

A group of blind girls were taken on country rambles to study wildflowers and trees, and to learn to distinguish the songs and notes of birds. Accounts of these trips were written by the student participants, one of whom was deaf-blind.

Dawson, James R. "Biology for the Blind." American Biology Teacher, Vol. 20, No. 2, pp. 42-44, February, 1958.

The use of modeling clay to create three-dimensional study models for blind biology students is described. Students manipulated clay chromosomes to conceptualize the events of mitosis and meiosis and also formed clay models of various human organs. It was concluded that blind students had the ability to form, retain, and recall what could be described as a "visual image" as well as their sighted peers.

de Haaff, Susan Jean. "A Creative Science Project for Blind Children." Journal of Visual Impairment and Blindness, Vol. 71, No. 10, pp. 458-459, December, 1977.

Presented is a lesson plan based on a conventional 5th grade science text and adapted to suit the needs of visually handicapped students. An experiment with yeast that shows how a one-celled plant multiplies and grows is described. A multi-sensory technique is employed to give the student a better understanding of the cause and effect relationship of nourishment, growth, and energy.

Demal, F. "Zue Praxis des Tastens." Zeitschrift für das oesterreichische Blindenwesen, Vol. 8, pp. 1449-1453, 1921.

Discussed is the practical use of the sense of touch in the education of the blind, with special emphasis on getting the most benefit out of available models and objects.

Egelston, Judy C. "Editorial Comment on Adapted Science Materials for the Blind (ASMB): Student Outcomes." Science Education, Vol. 59, No. 2, pp. 235-236, Spring, 1975.

This article prefaces research on ASMB by Linn and Their (1975). Intended for the regular public school science teacher with mainstreamed, visually handicapped students, this article briefly discusses some myths and facts related to educating the blind.

Eichenberger, Rudolph J. "Teaching Science to the Blind Student." Science Teacher, Vol. 41, No. 9, pp. 53-54, December, 1974. EJ 109 937.

This study describes how to adapt physical science laboratories which depend on visual data input for blind students. Also given are instructions for graph construction, use of the tape recorder, solving mathematical problems with a braille abacus, and other suggestions for physical science labs.

Enis, Carol A. and Michael Cataruzolo. "Sex Education in the Residential School for the Blind." Education of the Visually Handicapped, Vol. 4, No. 2, pp. 61-64, May, 1972.

The problems related to sex education and the visually handicapped are discussed. The results of a questionnaire seeking information regarding programs in sex education in all of the U.S. residential schools for the blind are summarized. Seventy-five percent of the schools responded in this report.

Evans, E. "Notes on Elementary Science." Teacher of the Blind, Vol. 15, pp. 113-115, 1927; and Vol. 16, pp. 10-12, 36-39, 1927.

A series of lessons in elementary level science is introduced.

Fisher, G. "Physik. Mell." Enzyklopädisches Handbuch des Blindenwesens, pp. 591-593, 1900.

Methods and materials for teaching physics in schools for the blind are described.

Fletcher, R. C., ed. The Teaching of Science and Mathematics to the Blind (with Section on Raised Diagrams): Report to the Viscount Nuffield Auxiliary Fund. London: Royal National Institute for the Blind, 172 p., 1973.

In 1965 the Viscount Nuffield Auxiliary Fund made to Worcester College for the Blind a two-year grant, later extended to three years, to encourage the development of science teaching in secondary schools for the blind and to try to give pupils in all schools for the blind a better opportunity to study mathematics in accordance with modern approaches. This book contains reports on various aspects of the project which involved science and mathematics teachers at the Royal National Institute for the Blind, Worcester College for the Blind, and several secondary schools for the blind throughout England.

Fletcher, R. C. "The Science Laboratory in a School for the Blind: General Science--A Suggested Two-Year Syllabus." The Teaching of Science and Mathematics to the Blind (with section on Raised Diagrams): Report to the Viscount Nuffield Auxiliary Fund, ed. R. Fletcher, London: Royal National Institute for the Blind, pp. 35-48, 1973.

The physical plan and equipment of science laboratories for the blind that are compatible with laboratories for the sighted are described. A two-year syllabus for general science emphasizing biology, hygiene, and chemistry is presented along with illustrations and applications of useful laboratory apparatus.

Francoeur, Pearl and Bihah Eilam. "Teaching the Mammalian Heart to the Visually Handicapped: A lesson in Concrete Experience." Science Teacher, Vol. 42, No. 10, pp. 8-11, December, 1975. EJ 130 198.

This study utilizes programmed instruction with concrete experiences and raised diagrams to teach the mammalian heart to an integrated high school classroom (one containing sighted and visually handicapped students).

Franks, Frank L. "Educational Materials Development in Primary Science: An Introductory Science Laboratory for Young Blind Students." Education of the Visually Handicapped, Vol. 7, No. 4, pp. 97-101, December, 1975. EJ 134 588.

This study provides a retrospective view of the early development of educational aids for the blind, describes the aids research effort at the American Printing House for the Blind, and presents an operational construct for the development of educational aids.

Franks, Frank L., and LaRhea Sanford. "Using the Light Sensor to Introduce Laboratory Science." Science and Children, Vol. 13, No. 6, pp. 48-49, March, 1976. EJ 138 577.

An instrument which affords blind students opportunities for direct observation, experimentation, and discovery is described. Accompanying the light sensor is a manual containing 25 experiments.

Franks, Frank L. "The Tactile Modality in Adapting and Developing Science Materials." Science Education and the Physically Handicapped: Sourcebook, eds. H. Hofman and K. Ricker, Washington, D. C.: National Science Teachers Association, pp. 189-199, 1979. (Stock No. 471-14760).

The history of adapting and developing tactile aids is discussed along with the changing attitudes of science educators towards the blind. Production guidelines from educational research into adapting and developing educational aids are presented, followed by a list of science materials and studies which utilized these research guidelines. The implications for other material needs are given.

French, R. S. "General Science: A Necessary Factor in a Modern Curriculum." American Association of Instructors of the Blind, Twenty-seventh Biennial Convention, pp. 152-154, June, 1924.

This report describes the principles, methods, and materials employed in adding a course in general science to the curriculum at the California School for the Blind. Classtime allotments and evaluation tests are also discussed.

Froneberg, E. "Naturgeschichte in der Blindenschule. Mell." Enzyklopädisches Handbuch des Blindenwesens, pp. 542-545, 1900.

Discussed in this article are the historical background of nature study in schools for the blind and the importance of the subject in the curriculum.

Fulker, Wilber H. and Mary Fulker. Techniques with Tangibles. Springfield, Ill.: Charles C. Thomas Publisher, 72 p., 1968.

This manual for teaching the blind with tangible apparatus was developed by the principal of the Blind School of the Colorado School for the Deaf and Blind and his wife. Much of the book is devoted to applications of the thermoform vacuum duplicating machine. Examples of thermoform masters which illustrate Mendel's Law, cell division, the human eye, and geographical and earth science maps are shown. Descriptions and illustrations of other handmade apparatus and models such as the suspension bridge, thermometer, vacuum and pressure pump, thermocouple, and solar system are given. Suggestions for adapting commercial teaching aids and toy models are also given. The use of field trips, concept corners, and creative art work is encouraged.

Gaedeke, C. "Der naturkundliche Unterricht in der Blindenanstalt." Blindenfreund, Vol. 7, pp. 97-101, 113-117, 129-132, 1887.

Presented is an explanation of how botany, zoology, minerology, and physics are taught in a German school for the blind, what equipment has been found necessary, and what means are used for connecting these subjects to the daily life of the students.

Gibson, Chester A. "Science Committee Notes." Teachers Forum, Vol. 4, No. 3 pp. 50, January, 1932.

Teachers of general science in schools for the blind are encouraged to use simple and inexpensive materials wherever possible to demonstrate important principles. As an example, an experiment showing the tremendous force exerted by the pressure of the atmosphere is presented.

Gibson, Chester A. "The Value of General Science to the Blind." American Association of Instructors of the Blind, Thirty-first Biennial Convention, pp. 771-773, July, 1932.

This report describes the history and popularity of general science courses in the secondary schools. Several objectives are recommended for the science teacher to include in the course: personal and community hygiene, orientation in the field of science, science applied to home maintenance, environmental principles in the community, developing problem solving abilities, and science related hobbies.

Gladstone-Millar, Linda. "Studying Science by Touch and Ear: An Edinburgh Course for the Blind and Partially Sighted." London Times Education Supplement, No. 3149, pp. 46-47, Friday, October 10, 1975.

The curriculum changes in science instruction at the Royal Blind School, Edinburgh, are reported. Two courses are briefly outlined: science for the general citizen and science for intending scientists. The advantages of including sighted students from a nearby high school in the programs are discussed.

Gold, Milton J. Hunter College Observation Television Center Catalog. New York: Hunter College of the City University of New York, 65 p., 1967. ED 018 912.

The catalog lists and annotates 112 titles of lessons first recorded on videotape and then transferred to film as kinescopes. The lessons are filmed in a specially prepared classroom equipped with remotely controlled cameras and microphones. During recording the class and teacher are alone in the classroom. Of this collection, five of the films are on the special education of the blind. The kinescopes may be rented (some may be purchased) for use in pre-service or in-service teacher education programs by public and private universities, colleges, secondary, and elementary schools.

Gough, Elva Ruth. "Common Sense and Sensitivity in Teaching the Blind." Science Education and the Physically Handicapped: Sourcebook, eds. H. Hofman and K. Ricker, Washington, D. C.: National Science Teachers Association, pp. 206-209. (Stock No. 471-14760).

For the public school science teacher with no experience in teaching the visually handicapped, this article describes steps to consider in accommodating a blind student in the science classroom, sources of materials, and practical suggestions for special instruction.

Gough, Elva Ruth. "Blind Students Succeed in the Lab--Any Lab." A Working Conference on Science Education for Handicapped Students, ed. H. Hofman, Washington, D. C.: National Science Teachers Association, pp. 96-101, 1978.

Several misconceptions harbored by science educators toward blind students in the science laboratory are discussed. Practical suggestions are offered for teaching basic chemistry skills, such as handling fire and corrosives and the accurate use of the balance; basic biology skills, such as measurement, dissection, and cell study; and astronomy. Skills for environmental field activities are also considered.

Graham, Milton D., ed. Science and Blindness: Retrospective and Prospective. New York: American Foundation for the Blind, 212 p., 1972.

The reports contained in this book grew out of the American Foundation for the Blind 50th Anniversary International Symposium on Science and Blindness, held in New York City in October, 1971. Contributions range from biostatisticians concerned with the numbers of blind people and their principal characteristics to engineers concerned with applications of space technology to problems of orientation and mobility.

Green, C. H. "Nature by Sound and Touch." Nature Magazine, Vol. 42, pp. 413-416, 452, 1949.

The nature study curriculum at the North Carolina School for the Blind is described.

Gunderson, R. W. "Blind Improved Test Gear." Radio Electronics, Vol. 22, No. 6, pp. 28-30, June, 1951.

Circuit testing devices developed for use by the blind are described.

Hadary, Doris E. "Picking Up Good Vibrations from Science for the Handicapped." Science Teacher, Vol. 42, No. 10, pp. 12-13, December, 1975. EJ 130 199.

This study describes the following programs for blind and handicapped students: a four-year science curriculum for elementary students and an enrichment science laboratory for secondary students.

Hadary, Doris E. "Laboratory Science and Art for Blind and Deaf Children." Science Education and the Physically Handicapped: Sourcebook, eds. H. Hofman and K. Ricker, Washington, D. C.: National Science Teachers Association, pp. 87-93, 1979. (Stock No. 471-14760).

This article describes a program at the American University of laboratory science and art for blind and deaf children. The project is a small, mainstreamed, multidisciplinary program for handicapped children which combines the inextricable elements of teacher training with emphasis on content and communication, curriculum design and implementation. Approximately 150 science lessons with matching art lessons have been designed, adapted, implemented, and tested in biological and physical sciences, interactions and systems, subsystems and variables, and energy sources.

Hadary, Doris E., Susan H. Cohen, Tamara Denise Hadary, and Ruth Levine. "Interaction and Creation Through Laboratory Science and Art for Special Children." Science and Children, Vol. 13, No. 6, pp. 31-33, March, 1976. EJ 138 569.

Experiments with adapted apparatus which allow blind children to discover principles are described. Individualized experiences, specifically designed, are developed in four curricula and a sample lesson is presented.

Hadary, Doris E. "Science and Art for Visually Handicapped Children." Journal of Visual Impairment and Blindness, Vol. 71, No. 5, pp. 203-209, May, 1977.

Described are the design, adaptation, and evaluation of a special four year program in laboratory science, art, and music for elementary school blind children.

Hamilton, Dale W. "The Laboratory in Schools for the Blind." American Association of Instructors of the Blind, Thirty-first Biennial Convention, pp. 775-777, July, 1932.

The performance and discussion of laboratory experiments by the science teacher instead of the active involvement of the blind student in the exercise is strongly discouraged. Many deficiencies in laboratory sciences for the blind are discussed and solutions are offered. Methods, materials, and guidelines for apparatus adaptation collected from successful residential school science programs are presented.

Hamilton, Dale W. "What Science Teaching is Advisable in Our High School Departments." American Association of Instructors of the Blind, Thirty-second Biennial Convention, pp. 131-136, June, 1934.

An argument for including sciences in the residential school curriculum is made and the benefits of science instruction for blind students are discussed. General science, hygiene, sex education, biology, and physics are sciences considered appropriate for blind students. The study of chemistry is discouraged because no satisfactory instructional program exists that permits laboratory applications.

Hance, R. T. "Laboratory Work for the Blind." Science Counselor, Vol. 1, No. 4, pp. 4, 34, April, 1935.

Laboratory work in biology performed by blind students enrolled in the University of Pittsburg is described.

Hance, R. T. "Mendelism for the Blind." Journal of Heredity, Vol. 27, pp. 151-153, 1936.

Described are laboratory courses in biological sciences that are being taught successfully to blind students at the University of Pittsburgh.

Harwood, R. "The Teaching of Science to Blind Students." The Teaching of Science and Mathematics to the Blind (with section on Raised Diagrams): Report to the Viscount Nuffield Auxiliary Fund, ed. R. Fletcher, London: Royal National Institute for the Blind, pp. 12-29, 1973.

A college class in advanced physics which integrates blind with sighted students is described. Illustrations, uses, and sources of special and adapted laboratory apparatus are presented.

Hatlen, Phillip. "Educational Research and Severe Visual Impairment." Science and Blindness: Retrospective and Prospective, ed. M. Graham, New York: American Foundation for the Blind, pp. 29-42, 1972.

The relation between educational research and the needs of practicing teachers of the blind is described. Research in the area of the visually handicapped is viewed to be of practical value and educationally sound when a close working relationship is established among educators, technologists, engineers, and scientists. The development of the Science Curriculum Improvement Study (SCIS) program is described along with several other projects as exemplary of the union between education and research.

Hayes, Julia L. "Museum Program at the Connecticut School for the Blind." New Outlook for the Blind, Vol. 46, No. 5, pp. 133-135, May, 1952.

The establishment of a program of regular weekly visits to the Children's Museum at Hartford is reported. The museum staff act as teachers.

Hebbeln, Harold J. "Adaptation in Teaching Physics to the Blind." Teachers Forum, Vol. 13, No. 2, pp. 54-58, November, 1941.

The nature of educational aids adaptation and its application to the study of physics is discussed. Current trends in methods of teaching physics are also described.

Hebbeln, Harold J. "Some Uses of Hearing in the Study of Physics." Teachers Forum, Vol. 4, No. 5, p. 91, May, 1932.

Described is a method of detecting small electrical currents through the sense of hearing.

Hebbeln, Harold J. "A Survey of Physics Courses in Schools and Classes for the Blind." Teachers Forum, Vol. 13, No. 2, pp. 26-30, November, 1940.

This survey attempts to determine to what extent physics is being taught in schools and classes for the blind, and what provisions have been made for laboratory work on the senior high school level.

Heisler, William T. "Tree Study." Outlook for the Blind, Vol. 38, No. 6, pp. 160-162, June, 1944.

A description of a course in dendrology, the study of trees and shrubs, undertaken at the Pennsylvania Institution for the Instruction of the Blind is presented.

Heisler, William T. "The Need for Three-Dimensional Instruction in Science Curricula." American Association of Instructors of the Blind, Thirty-eighth Biennial Convention, pp. 103-104, June, 1946.

Subtleties of tactual discriminatory skills are listed and a method of classifying sensory aids is presented. Methods of teaching the blind are viewed as fitting into three general categories: words, partial experiences, and full experiences. The role of three-dimensional contact experiences in subjects studied is discussed as it relates to pupil comprehension.

Henderson, David R. "Laboratory Methods in Physics for the Blind." Pittsburg, Pa.: University of Pittsburg, 77 p., September, 1967. ED 011 155.

The paper describes auditory and tactile adaptations of physics laboratory apparatus for use by blind students, together with five methods of drawing raised line and indented diagrams for use in physics experiments. A survey of physics laboratory methods in schools for the blind in the United States and seven foreign countries, and two simple physics experiments for blind high school students are included.

Hershkowitz, Aaron. "Conservation of Quantity, Mass, and Volume in Blind Children." Social Research on Blindness: Present Status and Future Potentials, ed. M. Graham, New York: American Foundation for the Blind, pp. 82-83, 1960.

A group of seven, young blind children, seven, blindfolded, sighted children, and seven sighted children were matched for age, intelligence, and socio-economic level and compared on abilities to conserve quantity in this investigation of the role of vision in solution of Piagetian conservation problems presented under varying conditions of instructions and modality. No conclusions were reported.

Hiemenz, Paul C. and Elizabeth Pfeiffer. "A General Chemistry Experiment for the Blind." Journal of Chemical Education, Vol. 49, No. 4, pp. 263-265, April, 1972. EJ 059 197.

This study describes a quantitative chemistry experiment, conductometric titration, which was adapted for a blind student. Also, other areas are indicated which can be adapted for similar experiments.

Hill, O. J. "Another Beam of Light through the Darkness." Teachers Forum, Vol. 11, No. 4, pp. 62-75, 72, March, 1939.

This article discusses how students at the Ohio State School for the Blind are given a more accurate idea of birds and animals, trees and buildings through models constructed on a WPA project.

Hill, O. J. "How Scaled Models are Used to Teach the Blind." American Association of Instructors of the Blind, Thirty-fifth Biennial Convention, pp. 145-147, June, 1940.

Methods of using educational models in science instruction at the Ohio School for the Blind are described.

Hofman, Helenmarie, Ed. A Working Conference on Science Education for Handicapped Students: Proceedings. Washington, D. C.: National Science Teachers Association, 392 p., April, 1978. ED 161 714.

This conference attempted to assess the state of the art and develop recommendations for new directions in science education and careers in science for handicapped students. Panel discussions were held on such

topics as: (1) attitudinal barriers and other obstacles to handicapped students; (2) current practices relating to all physical handicaps; (3) mainstreaming and the law; (4) current practices related to auditorially handicapped students; (5) visually handicapped students; (6) science education, the handicapped, and careers; (7) orthopedically handicapped students; and (8) science careers for handicapped students. Through working sessions the conference participants developed a position statement of science education for the physically handicapped student. Recommendations for action are addressed to various groups.

Hofman, Helenmarie H. and Kenneth S. Ricker, eds. Science Education and the Physically Handicapped: Sourcebook. Washington, D. C.: National Science Teachers Association, 285 p., 1979. (Stock No. 471-14760).

This sourcebook is an attempt to distribute on a national level the proceedings of the 1978, National Science Teachers Associations's conference on science education for handicapped students (Hofman, 1978). The articles and papers have been divided into ten sections: "Science Education and the Handicapped," "Science for Everyone," "Preparing Teachers to Work with the Handicapped," "Resources for Teachers/Schools," "Science and the Auditory Handicapped," "Science and the Orthopedic Handicapped," "Science and the Visually Handicapped," "Extending the Science Program Beyond the School," "The Handicapped and Careers in Science and Related Fields," and "Science Education and the Handicapped, Implications for the Future."

Hoover, William C. "The Technique of Physics Instruction for the Blind." Teachers Forum, Vol. 9, No. 4, pp. 73-78, March, 1937.

Outlined in this article are the teaching methods employed in physics classes at the Kansas School for the Blind.

Hurst, A. D. "Ways and Means of Teaching General Science to Blind Students." Teachers Forum, Vol. 6, No. 2, pp. 34-37, November, 1933.

This report describes how some laboratory equipment and experiments useful to general science instruction can be adapted for blind students. Simple laboratory exercises are presented on the topics of molds, yeasts, major organs, leaf structures, flower parts, tree identification, generation of gases, weather, distillation, refrigeration, electricity, and astronomy.

Johnston, Susanne C. "Science for a Partially Sighted Junior High Child." Science Education and the Physically Handicapped: Sourcebook, eds. H. Hofman and K. Ricker, Washington, D. C.: National Science Teachers Association, pp. 66-72, 1979. (Stock No. 471-14760).

This article describes how a junior high science teacher in a public school adapted course instruction to accommodate a mainstreamed, partially sighted student. Topics discussed include changes in classroom materials, use of sighted lab assistants, and approaches to teaching microscope work, genetics, chromatography, capillary action, and diseases.

Joint Committee of the College of Teachers of the Blind and the National Institute for the Blind. The Education of the Blind: A Survey. London: Edward Arnold Co., pp. 129-132, 1936.

Reported are the findings of the Committee in regard to nature knowledge and elementary science in schools for the blind.

Kaufman, Abraham S. "Tutoring a Visually Handicapped Student in High School Chemistry." New Outlook for the Blind, Vol. 65, No. 10, pp. 313-317, December, 1971. EJ 048 860.

Described are teacher developed materials and techniques used by a high school teacher for tutoring a visually handicapped student in high school chemistry.

Koehne, Grace. "The Place of Science in the Elementary Curriculum." American Association of Instructors of the Blind, Thirty-second Biennial Convention, pp. 125-127, June, 1934.

The importance of science instruction in the elementary grades is discussed and the science curriculum in grades 1-8 at the Indiana School for the Blind is described. Results of a national survey of residential school elementary science programs are presented. At that time, only ten schools in the U.S. had such programs.

Kraus, S. "Physik in der Blindenschule." Blindenfreund, Vol. 22, pp. 27-28, 1902.

This article contains directions for making certain experiments in physics intelligible to blind students.

Laetsch, F. "SAVI (Science Activities for the Visually Impaired)." Berkeley: Lawrence Hall of Science, University of California, 1977.

Reported is a partially completed program of individualized, hands-on, science activities for visually impaired students age 9-12. Two activity modules, "Structure of Life" and "Scientific Reasoning," are described.

Langworthy, Jessica L. "An Experiment in Teaching Astronomy." Teachers Forum, Vol. 7, No. 3, pp. 53-55, January, 1935.

Described is a brief course of twelve lessons, given at Perkins Institution, covering the story of the solar system, the tides, the history of the calendar, the principal constellations, and other similar topics.

Lennon, Elizabeth M., John L. Feirer, and William K. Purdy. "Metrics for Visually Impaired Persons." New Outlook for the Blind, Vol. 70, No. 1, pp. 1-4, January, 1976.

The Center for Metric Education at Western Michigan University, under a U.S. Office of Education grant entitled "Metric Conversion in Vocational Education," has developed a number of aids to be used by visually impaired persons in learning and using the metric system. Linear measurements (and their relationships to volume and weight) for general use and measures commonly used in the kitchen have been emphasized.

Levine, Helen G. and Muriel C. Lass. "Recorded and Braille Textbooks: Everything the Blind Student Needs to Know: The National Braille Association." New Outlook for the Blind, Vol. 40, No. 7, pp. 516-517, April, 1974.
EJ 101 050.

Textbooks in braille are prepared by certified volunteer transcribers all over the country. Master copies of over 1,100 textbooks, from which thermoformed duplicates can be made, are located in the Braille Book Bank of the National Braille Association. Nearly 200 scientific and mathematical tables in braille are available through the Association's Braille Technical Tables Bank. The Instructional Materials Reference Center maintains a Central Catalog of braille books and their location in various other depositories. Full instructions for the use of the various services of Recording for the Blind, Inc. and the National Braille Association are included in this two-part article.

Lindecker, Ruth C. "Teaching Human Reproduction to the Visually Impaired in Science Classes." A Working Conference on Science Education for Handicapped Students, ed. H. Hofman, Washington, D. C.: National Science Teachers Association, pp. 108-113, 1978.

This report addresses the unique problems of teaching human reproduction and sexuality to the blind. No definite solution is offered after the scope of the problem is discussed. However, a wide range of suggestions is presented for the science teacher to consider in meeting the individual needs of the student. Parental involvement in securing live models is encouraged.

Long, R. E. "The Importance of a Laboratory in Science Classes--What Shall be in It?" American Association of Instructors of the Blind, Thirty-fifth Biennial Convention, pp. 173-175, June, 1940.

Discussed is the importance of the laboratory for adding concrete experiences to the study of sciences in grades 1-12. Although specific examples of appropriate laboratory apparatus are omitted in this discussion, consideration is given to the philosophy of the laboratory in residential school science programs in hopes that agreement on approach will permit suitable solutions to the problems of materials acquisition.

Loomis, Madeline S. and Paul C. Mitchell. Braille Chemical Notations and How to Use Them. New York: New York Institute for the Education of the Blind, Monograph No. 8, 28 p., 1939.

The rules and symbols for braille chemical notations contained in this booklet were developed during three years of class and laboratory work in chemistry at the New York Institute for the Education of the Blind. These symbols have been selected with great care, used under actual laboratory conditions, and have served well in preparing pupils for college entrance and New York State Regents examinations.

Lowenfeld, Berthold. "Education Models in Schools for the Blind." Outlook for the Blind and Teachers Forum, Vol. 36, No. 1, pp. 35-37, February, 1942.

Modern psychological concepts of learning have exerted a strong influence on teaching methods in schools for the blind. Efforts are being made to prepare and collect educational models intended to give blind children concrete experience with objects.

Maley, Patrick V. "Suggestions for Using the Senses in Teaching Science." American Association of Instructors of the Blind, Fortieth Biennial Convention, pp. 125-127, June, 1950.

Suggestions for increasing olfactory, gustatory, cutaneous, and static sensitivity are presented to provide insight into the development of new laboratory projects for blind science students. An example is given of a physics exercise on the relativity of motion.

Malone, Lawrence and Linda DeLucchi. "Life Science for Visually Impaired Students." Science and Children, Vol. 16, No. 5, pp. 29-31, February, 1979.

This article describes how selected Science Activities for the Visually Impaired (SAVI) lessons were applied in a class of visually handicapped students to enrich science learning experiences. Activities with live crayfish, snails, and plants are presented and a method of integrating the experiences of indoor and outdoor biology activities is presented.

Maynz, J. "Gipsmodelle im Blindenunterricht." Arbeitschule, Vol. 44, pp. 248-250, 1930.

Directions are presented for making plaster models for use in the science education of the blind.

McHugh, Dorothy A. "The Teaching of Chemistry in a School for the Blind." The Teaching of Science and Mathematics to the Blind (with section on Raised Diagrams): Report to the Viscount Nuffield Auxiliary Fund, ed. R. Fletcher, London: Royal National Institute for the Blind, pp. 30-32, 1973.

Specific suggestions for conducting certain laboratory experiments in chemistry are presented.

McIntyre, Margaret. "Early Childhood and Science: Science is for All Children." Science and Children, Vol. 13, No. 6, pp. 50-51, March, 1976. EJ 138 578.

Some ways in which exploratory activities of the preschool child involve science concepts are described, the role of the adults' knowledge about both science and child development is stressed. Emphasis is placed on hands-on experiences.

Meisinger, F. "Der Unterricht in der Naturgeschichte. Mell." Blindenunterricht, pp. 154-170, 1910.

Suggestions and directions are provided for teaching anatomy and hygiene, zoology, botany, and mineralogy in a school for the blind. Much of the paper discusses the advantages of field trips.

Mell, M. "Der Unterricht in der Naturlehre. Mell." Blindenunterricht, pp. 170-179, 1910.

Discussed are methods and materials useful in teaching general science in a school for the blind.

Miller, Marion, "A Circus in the Primary Grades." Outlook for the Blind, Vol. 23, No. 2, pp. 25-27, September, 1929.

This article describes how nature study is made alive and interesting to blind children through the staging of a circus.

Mitchell, Paul C. "Some Ways of Teaching Attitudes and Methods in Science." American Association of Instructors of the Blind, Thirty-fifth Biennial Convention, pp. 171-172, June, 1940.

Consideration is given to the realm of science instruction as an ideal place for developing proper attitudes and methods of life, especially for the blind student. General aims in teaching science and specific objectives of an enriched science program are presented.

Myers, S. O. "The Teaching of Science in Schools for the Blind." Teacher of the Blind, Vol. 23, pp. 90-93, 1935.

An outline for a course in general science study is presented.

Myers, S. O. "General Science in Schools for the Blind." Outlook for the Blind, Vol. 37, No. 3, pp. 72-73, March, 1943.

The suggestion is made that the general science syllabus be divided into three parts: an introductory period for pupils below the age of 13, the senior school main course, and a scheme for continuation classes.

Myers, S. O. "Current Research into the Teaching of Primary School Science." The Teaching of Science and Mathematics to the Blind (with section on Raised Diagrams): Report to the Viscount Nuffield Auxiliary Fund, ed. R. Fletcher, London: Royal National Institute for the Blind, pp. 160-161, 1973.

Described is a research project related to the training of science to blind primary pupils, age five to eleven, of normal intelligence and secondary students, age 12-16, of below average ability. The project emphasizes student discovery and exploration of environmental concepts.

Napier, Grace D. "Special Subject Adjustments and Skills." The Visually Handicapped Child in School, ed. B. Lowenfeld, New York: The John Day Company, pp. 221-277, 1973.

Methodology is presented for teaching science to the blind in this chapter which also includes methods in mathematics, social sciences, music, arts and crafts, foreign languages, home economics, and physical education. Techniques for teaching hygiene, human reproduction, earth and space sciences, chemistry, physics, and biology are discussed. Emphasis is given to employing sensory approaches and a broad variety of enrichment activities is listed for each subject area.

National Academy of Sciences. "Science and Technology in the Service of the Physically Handicapped: Summary." National Academy of Sciences-National Research Council, Division of Medical Sciences, Washington, D.C., 30 p., August, 1976. ED 151 996.

The report of the committee on national needs for the rehabilitation of the physically handicapped focuses on the current problems in the field, the areas in which additional knowledge is needed, and directions in which society and government should move both with respect to the acquisition of new knowledge and a more effective organization of effort. Listed among recommendations is that for major areas of disability, a comprehensive national overview should be developed outlining in full its demography, national cost, and related social and organizational structure. Rehabilitation is discussed in terms of the medical and social framework, demography, organizations and programs, the policy picture, and economics. A section on the state of the art in science and technology and their application covers research and development, blindness and low vision, hearing and speech, manipulation and locomotion, and basic neuroscience and rehabilitation.

National Institute for the Blind. Museums and the Blind. London: National Institute for the Blind, Bulletin No. 2, 12 p., 1930.

This report presents a survey of the use made by public museums in the instruction of the blind, with a list of English museums prepared to offer special facilities to the blind.

National Science Teachers Association. "Bibliography: Science and the Visually Handicapped." Science Education and the Physically Handicapped: Sourcebook, eds. H. Hofman and K. Ricker, Washington, D. C.: National Science Teachers Association, pp. 111-115, 1979. (Stock No. 471-14760).

This bibliography contains 64 entries related to science education and the visually handicapped.

Ohio Works Project Administration Writers' Program. Models for the Blind. Columbus: Ohio School for the Blind, 197 p., 1941.

Described is a collection of models constructed by a WPA project for the Ohio School for the Blind.

Oppel, F. "Die Naturgeschichte in Blindenanstalten." Blindenlehrerkongress, Frankfurt, pp. 198-209, 1882.

Discussed are methods of teaching botany, zoology, and mineralogy in schools for the blind.

Overbeay, Donald W. "Enriching and Extending the Science Program to Meet Post-War Needs." American Association of Instructors of the Blind, Thirty-eighth Biennial Convention, pp. 100-102, June, 1946.

This report recommends that science be taught in schools for the blind from grades one through twelve. Science is viewed as the best medium in educating youth for participation in a democracy. The principle objectives of science instruction are outlined and suggestions are offered for enriching the science program.

Overbrook School for the Blind Staff. "Practical Physics at Overbrook." Outlook for the Blind, Vol. 36, No. 5, pp. 296-298, December, 1942.

Described is a course which emphasizes the laws and practical applications of physics rather than the more technical and abstract phases of the subject.

Pappas, Christos, Jr. "Teaching Chemistry at Perkins." American Association of Instructors of the Blind, Fortieth Biennial Convention, pp. 127-129, June, 1950.

This paper describes the course in chemistry at Perkins Institution as a tailored, trimmed, and streamlined course taught on the basis of student interest and relation to daily living, as opposed to a chemistry course taught in a "college dictated" manner. The content of class lectures and laboratory experiments is discussed along with solutions to the special problems encountered.

Pease, Loretta C. "The Science Laboratory in the Elementary School for the Blind." Outlook for the Blind and Teachers Forum, Vol. 40, No. 6, pp. 159-164, June, 1946.

The importance of elementary level science programs in schools for the blind is discussed and criteria for selecting indoor and outdoor laboratory equipment is presented. To illustrate the organization of outdoor laboratory equipment and the value of simple indoor equipment to supplement it, detailed programs on trees and gardening for primary age blind students are provided. Many questions that teachers and students might ask are addressed.

Perkins, H. F. "Helping the Blind to 'See' a Museum." Red Cross Courier, Vol. 19, No. 11, pp. 17-18, November, 1940.

This report describes the Robert Hull Fleming Museum which holds exhibitions for and by the blind and which circulates a seventy-five object collection of various specimens.

Peterson, Edwin G. "The Extent and Importance of Laboratory Work in Biology Classes." American Association of Instructors of the Blind, Thirty-fifth Biennial Convention, pp. 158-161, June, 1940.

Current practices in teaching biology to the blind are described and curriculum deficiencies are addressed. Basic objectives of teaching biology to the blind are listed as well as these general principles: (1) Use real materials in preference to models, but, when models must be used, have them as life-like and life size as possible; (2) Teach what is of immediate interest, that is, local flora and fauna; (3) Do as much practical laboratory and field work as possible; and (4) Study nature in its natural state.

Pickles, A. O. "Radionic Constructional and Experimental System." The Teaching of Science and Mathematics to the Blind (with section on Raised Diagrams): Report to the Viscount Nuffield Auxiliary Fund, London: Royal National Institute for the Blind, pp. 49-52, 1973.

Described is a systematic method of constructing radio and electronic circuits without the need for soldering that can be easily assembled, adapted, or dismantled without damaging delicate components. Designed for the blind student, the system is in complete harmony with the modern physics syllabus in England.

Piltz, Albert. "Gardening for the Blind Child." Science and Children, Vol. 6, No. 2, p. 25, October, 1968.

A set of gardening tools specially developed for visually handicapped students in the Detroit Public Schools is reported. A planting board, router, and brailled plant markers were used by blind students to plant, tend, and harvest a garden crop during a one year period.

Prilop, P. "Das Problem des Naturgeschichtsunterrichts in der Blindenschule." Blindenfreund, Vol. 52, pp. 252-257, 1932.

A survey of 35 students in a school for the blind brought out the fact that nature study was of predominating interest to most of them. Discussed are various suggestions for making the subject intelligible to the blind student.

Ramsey, G. F. Educational Work in Museums of the United States. New York: H. W. Wilson Co., pp. 97-105, 1938.

Chapter V, "Museum Work for Handicapped Children," tells of classes for blind children given at the American Museum of Natural History in New York and by museums in other parts of the country.

Riddle, C. F. "Science in the Elementary Grades." American Association of Instructors of the Blind, Thirty-eighth Biennial Convention, pp. 105-107, June, 1946.

The theme of this paper is that science should supply the materials for the basic concepts of learning; that without clear concepts of, and experience with, the objects and materials of one's environments, learning is impossible; and that the most frequently met barrier to educational progress is the lack of such concepts and experiences. The importance of science in early childhood is discussed as it relates to learning through concrete experiences.

SAVI Newsletter. Science Activities for the Visually Impaired, Berkeley, California, February, 1977; January, 1978; January, 1979.

SAVI (Science Activities for the Visually Impaired) involves many of the same team that produced SCIS (Science Curriculum Improvement Study) with their endeavors at the Lawrence Hall of Science in Berkeley, California. The purpose of this program is to design a series of individualized activities to make concrete experiences in science available to visually impaired children from 9 to 12 years of age. These newsletters contain reports from field testing and materials development through national teacher trials in order to get information and feedback which can be used to make SAVI activities as effective and helpful as possible to the broadest spectrum of visually impaired youths.

Schatz, Dennis and Holly Overman. "The Role of the Science Museum in Science Education of the Handicapped." Science Education and the Physically Handicapped: Sourcebook, eds. H. Hofman and K. Ricker, Washington, D. C.: National Science Teachers Association, pp. 237-241, 1979. (Stock No. 471-14760).

Developed is the idea that science museums are natural locations for resource centers that provide in-service workshops concerning the teaching of science to handicapped students and for depositories for loan of adapted science activities, aids, and appliances. Particular attention is given to resources for the visually handicapped that have a broad application across disability areas.

Schatz, Dennis and Herbert D. Their. "Increasing the Accessibility of Hands-On Science for Blind Students." New Outlook for the Blind, Vol. 70, No. 2, pp. 61-63, February, 1976. EJ 136 181.

The Adapting Science Materials for the Blind (ASMB) project has developed a number of individualized sets of science activities and experiments for upper-elementary level visually handicapped students. Working independently or in small groups, students are able to learn fundamental scientific principles and the basics of the scientific method using the hands-on approach. The ASMB materials are tested in actual classroom situations and then refined further.

Schatz, Denis, Frank L. Franks, Herbert D. Their, and Marcia C. Linn. "Hands-On Science for the Blind." Science and Children, Vol. 13, No. 6, pp. 21-22, March, 1976. EJ 138 566.

This study stresses the fact that science activities can be styled to the visually handicapped students' levels and degrees of independence. Use of extensive hands-on, concrete experiences as emphasized by Adapting Science Materials for the Blind (ASMB) is encouraged.

Schnur, Ronald and Carl Bergen. "SAVI (Science Activities for the Visually Impaired): Developing a New Science Curriculum." Association of Educators of the Visually Handicapped: Proceedings, 54th Conference, pp. 42-46, June, 1978.

Content and design principles of Science Activities for the Visually Impaired (SAVI) are described. The program consists of nine, individualized, hands-on, science activity modules, containing two to eight activities per module that can be used by students nine to twelve years of age with great flexibility and without the need of specialized equipment.

Schwartz, Jonathan R. "Survey of Nature Trails for the Visually Impaired." Journal of Visual Impairment and Blindness, Vol. 71, No. 2, pp. 54-61, February, 1977.

In order to develop design criteria for interpretive nature trails for the visually impaired, this study first investigated existing trails to determine how effective they were, and to discover what problems have emerged in their administration. Since it was not feasible to survey visually handicapped persons directly, certified orientation and mobility instructors were surveyed to obtain information on the opinions of visually impaired persons.

Science for the Blind. Science for the Blind. Bala Cynwyd, Pa.: Science for the Blind, 70 p., 1967. ED 018 055.

The report on Science for the Blind, a non-profit organization, details past and planned growth. The organization has been providing scientific information on tape since 1955. Over 2,000 tapes are currently circulated monthly, with selections from scientific periodicals, lectures, and books. In 1964 the instrument and aids project was begun to provide special instruments and apparatus to the blind working in scientific and technical fields so that they could compete on a more equal basis with their sighted co-workers. The project also aims to assist any blind person who needs instruments to perform tasks connected with hobbies and everyday life, as well as work. Included in this report are the organization's financial requirements and descriptions of the jobs within it. Current and future projects and equipment are detailed.

SCIS Newsletter. The Science Curriculum Improvement Study, Berkeley, California. No. 20, Spring, 1971; No. 22, Winter, 1971; No. 23, Fall, 1972; No. 24, Spring, 1973.

Updated information on field testing and materials development of the SCIS (Science Curriculum Improvement Study) program adapted for visually handicapped students is presented in these newsletters.

Sharpless, Nansie S., Geerat Vermeij, and John Gavin. "Achievement in Science." Science Education and the Physically Handicapped: Sourcebook, eds. H. Hofman and K. Ricker, Washington, D. C.: National Science Teachers Association, pp. 42-47, 1979. (Stock No. 471-14760).

This account contains a brief autobiography of Dr. Geerat Vermeij, a blind professor of zoology at the University of Maryland, who completed his undergraduate work at Princeton and received his Ph.D. from Yale. Obstacles to his educational and career pursuits are discussed.

Sheldon, D. D. The Blind Child in the World of Nature. New York: American Foundation for the Blind, 8 p., 1929.

A nature study project conducted at the Department of Special Studies at Perkins Institution is reported.

Shagrue, Sylvia K., Walter M. Morris, and Carolyn H. Kuhne. "Braille Trail Model." Science and Children, Vol. 6, No. 2, pp. 23-24, October, 1968.

This report describes the development of a raised relief map for use by blind people who visit the Touch and See Nature Trail at the National Arboretum. The three-dimensional scale model of the trail was developed as a school project for sighted primary classes in a public school.

Stainton, Edna. "Nature Study Class." Outlook for the Blind, Vol. 24, No. 1, pp. 34-35, June, 1930.

This article reports that a class of fifteen blind students was held by the Buffalo Association for the Blind under the auspices of the Buffalo Museum of Natural Science for the purpose of making the blind more familiar with certain phases of nature study.

Stelle, May. "The Introduction of Science in the Intermediate Grades." American Association of Instructors of the Blind, Thirty-eighth Biennial Convention, pp. 67-72, June, 1946.

The study of science is discussed as it relates to the child's knowledge of the environment through concrete experiences. Principles of science instruction as practiced in the intermediate grades of the Florida School for the Deaf and Blind are presented. Beginning science instruction in the primary grades is encouraged.

Stephens, W. Beth, Joseph Fitzgerald, Jo Hitt, and Carl Grube. Student Activity Guide: A Piagetian Perspective. Richardson, Texas: University of Texas at Dallas, 193 p., 1977. (Grant No. G00-74-07445, Project No. 443 CH 50410).

Application of Piagetian-based strategies in classrooms with visually handicapped students has resulted in this student activities manual which has numerous modules on classification, conservation, spatial relations/mental imagery, and abstract (formal) operations.

Stephenson, S. C. "The Teaching of Science at Worcester College for the Blind." The Teaching of Science and Mathematics to the Blind (with section on Raised Diagrams): Report to the Viscount Nuffield Auxillary Fund, ed. R. Fletcher, London: Royal National Institute for the Blind, pp. 7-12, 1973.

The science curriculum at Worcester College for the Blind which focuses on biology and chemistry is described. A description is also included of the program's educational materials: textbooks, embossed diagrams, recorded journal articles, special and adapted laboratory devices.

Stephenson, S. C. "Further Notes on Teaching Science to the Blind." The Teaching of Science and Mathematics to the Blind (with section on Raised Diagrams): Report to the Viscount Nuffield Auxiliary Fund, ed. R. Fletcher, London: Royal National Institute for the Blind, pp. 162-165, 1973.

This article updates the list of laboratory apparatus which has been found useful in teaching general science, biology, chemistry, and physics at Worcester College for the Blind.

Their, Herbert D. "Fostering Observation in a Science Program for the Young Blind Student." Science Education and the Physically Handicapped: Source-book, eds. H. Hofman and K. Ricker, Washington, D. C.: National Science Teachers Association, pp. 200-205, 1979. (Stock No. 471-14760).

This article discusses the value of observation in science and describes the typically found approaches to teaching observation to the young blind student with a focus on the shortcomings of these approaches. The author emphasizes what is possible for the blind student and describes the materials development of the Science Curriculum Improvement Study (SCIS) program adapted for the visually impaired.

Their, Herbert D. and others. Adapting Science Materials for the Blind, Report of an Evaluation Planning Conference. Berkeley, Calif.: California University, 11 p., December, 1969. ED 038 282.

Persons from the field of science education and persons who had extensive experience working with visually handicapped children were brought together to establish some baselines and beginning ideas of approaches to the evaluation of a laboratory-centered science program (Science Curriculum Improvement Study) as it is being used with visually handicapped children. Areas in which participants were in agreement relative to evaluation in the project are discussed.

Tallman, Dennis E. "pH Titration Apparatus for the Blind Student." Journal of Chemical Education, Vol. 55, No. 9, pp. 605-606, September, 1978.

Described is the adaptation and application of a Beckman Zeromatic II pH meter for use by a blind college student enrolled in an analytic chemistry course. The adaptations allowed the student to gain experiences with analyzing changes in solution composition when titrant is added in neutralization titrations.

Their, Herbert D. "Laboratory Science for Visually Handicapped Elementary School Children." New Outlook for the Blind, Vol. 65, No. 6, pp. 190-194, June, 1971.

This report describes the adaptation of the Science Curriculum Improvement Study, an ungraded, sequential, physical and life science program for the elementary school, for use by visually handicapped students. The purpose of Adapting Science Materials for the Blind is to provide an experience-centered instructional program in science; a program which in essence turns the classroom into a laboratory.

Their, Herbert D. and Doris E. Hadary. "We Can Do It, Too." Science and Children, Vol. 11, No. 4, pp. 7-9, December, 1973. EJ 091 642.

This study describes some of the adaptations of science exercises found in the program, Adapting Science Materials for the Blind. This program enables blind and other visually impaired pupils to participate in the activities of the Science Curriculum Improvement Study.

Their, Marlene. "Utilizing Science Experiences for Developing Visual Perception Skills." Science and Children, Vol. 13, No. 6, pp. 39-40, March, 1976. EJ 138 573.

Described are alternative approaches for developing visual perception skills found in using selected science experiences. Use of various science programs available, such as ESS, SCIS, OBIS, and MATAL, is suggested. Visual sequencing is prescribed and described.

Thomas, Barry. "Environmental Education for the Blind." Instructor, Vol. 86, No. 9, pp. 106-107, May, 1977.

Six lesson plans used with blind multihandicapped students in an environmental education workshop are presented. The goals for each lesson include making a predator device that can catch a prey, creating an animal and a plant that can survive in a particular niche, finding different plants, inventing ways of seed dispersal, and studying animal motion.

Tombaugh, Dorothy. "Laboratory Techniques for the Blind." American Biology Teacher, Vol. 34, No. 5, pp. 258-260, May, 1972. EJ 061 279.

This study describes modifications of laboratory procedures for the BSCS Green Version Biology, including dissection, microbiology, animal behavior, physiology, biochemistry, and genetics that make the methods suitable for direct experimentation by blind students. Also discussed is the use of models as substitutes for microscopy.

Tombaugh, Dorothy. "Mainstreaming Visually Handicapped in Biology." A Working Conference on Science Education for Handicapped Students, ed. H. Hofman, Washington, D. C.: National Science Teachers Association, pp. 167-171, 1978.

The use of sighted lab partners is encouraged as a method for teaching high school biology to the blind. Helpful suggestions and adaptations are presented for laboratory work involving microscopy, dissection, bio-chemical equations, and the study of genetics. A minimum of special equipment is recommended and several alternative strategies are discussed for laboratory exercises involving organisms or materials that are inappropriate for blind students, such as the substitution for Tes-tape of limewater, silver nitrate, and other solutions that produce precipitates.

Tombaugh, Dorothy. Biology for the Blind. Euclid, Ohio: Euclid Board of Education, 75 p., 1973. ED 077 677.

This manual provides advice and guidance to teachers of biology who may have blind children in a class of students with normal sight. The author stresses that in the objectives of high school biology curricula, there is no goal that is beyond the reach of a blind person. The first section provides suggestions for assisting blind students under the following headings: class orientation, laboratory assistants, classroom procedures, tests, equipment, and

techniques. The second section is a teachers' guide to Biological Sciences Curriculum Study (BSCS) green version high school biology for blind students. Here the author gives specific suggestions and advice on techniques which enable the blind student to take a fully active role in laboratory investigations. Also listed are supplementary readings in biology (available as recordings), supplementary biology materials, and sources of materials for the blind.

True, Nancy A. "Museum Work for Partially and Totally Blind Children." Teachers Forum, Vol. 2, No. 3, pp. 2-4, January, 1930.

The work of the American Museum of Natural History with classes of blind and partially sighted children is described.

Turner, Sadie. "Making Use of our Museum." Teachers Forum, Vol. 2, No. 3, pp. 12-13, May, 1930.

This article reports that models from the museum at Perkins Institution were used to illustrate simple stories of animals and birds in elementary nature study.

Vaughn, R. "A Course in Nature Study and Science." Teacher of the Blind. Vol. 17, pp. 288-289, 1929; and Vol. 18, pp. 11-12, 37-39, 63-64, 90-91, 114-115, 1930.

A course of study in six stages, each stage divided into three terms, with ten lessons suggested for each term, is presented.

Walker, I. Constance. "Computer Programming for the Blind and Visually Impaired: A Case for Quality Standards and Professionalism." American Foundation for the Blind Research Bulletin, No. 24, pp. 95-112, March, 1972.

The purpose of this paper is to specify a bench-mark standard for the quality training of blind and visually impaired computer programmers. Training methods are described which, on the basis of several years of experience, have produced graduates who are competent.

Walker, I. Constance. "Preparing the Severely Visually Impaired for the Professions." Science and Blindness: Retrospective and Prospective, ed. M. Graham, New York: American Foundation for the Blind, pp. 73-79, 1972.

Methods of training blind computer programmers at Systems Development Corporation are presented which have produced competent, well paid, computer professionals. The use of sighted partners is employed in training and no equipment has been specially adapted for the blind worker.

Wanecek, O. "Über Lehrmittel in tierkundlichen Unterricht." Zeitschrift für das oesterreichische Blindenwesen, Vol. 2, pp. 311-313, 1915.

This article discusses the use of objects and models in zoology classes in schools for the blind.

Waterhouse, Edward J. "Enrichment Through Models." American Association of Instructors of the Blind, Thirty-fifth Biennial Convention, pp. 148-149, June, 1940.

The advantages and limitations of models are discussed and criteria for selecting and developing models are presented.

Weems, Bruce. "A Physical Science Course for the Visually Impaired." Physics Teacher, Vol. 15, No. 6, pp. 333-338, September, 1977. EJ 166 574.

This study describes a university level laboratory science course designed for visually handicapped students.

Wellington, J. A. and D. H. Morgan. "Visual Aids in the Teaching of Astronomy to the Blind." Teachers Forum, Vol. 12, No. 4, pp. 66-67, 72, March, 1940.

Presented is an illustrated description of several models, showing the relations between the sun, moon, and earth, which have been constructed at the California School for the Blind.

Wexler, A. Experimental Science for the Blind. London: Pergamon Press, 1963.

This manual contains many illustrations and descriptions of various science activities and laboratory experiments that have been used successfully with visually handicapped science students in England and Australia.

Whitfield, Eddie. "Experiments on Tape." Science and Children, Vol. 13, No. 6, pp. 47, March, 1976. EJ 138 576.

The use of science experiments on tape are shown to provide for individual differences from the gifted child to the handicapped in developing skills in the language art area, developing significant concepts, and making learning come alive.

Willoughby, Doris, Shirley Lansing, Mary Barber, and Patricia Maurer. Your School Includes a Blind Student, Chatsworth, Calif.: National Federation of the Blind, Teachers Division, 36 p., 1978.

The Teachers Division of the National Federation of the Blind offers this booklet as a guide for the genuine integration of the blind student into the regular educational system, as a preparation for normal, responsible adulthood. Included in this comprehensive guidebook are suggestions for teaching science. The use of sighted laboratory partners is recommended.

Witcher, Clifford M. "Laboratory Work for the Blind." Blindness: Modern Approaches to the Unseen Environment, ed. P. Zahl, Princeton, N. J.: Princeton University Press, pp. 247-258, 1950.

Popular misconceptions regarding the blind working in laboratory sciences are dismissed and support is given to the increasing needs of blind students to take laboratory courses. Desirable qualifications for blind laboratory workers and laboratory work in schools for the blind are reviewed. Case studies of four blind, successful, laboratory scientists are examined and suggestions for blind students wishing to pursue laboratory work are offered. Research as a possible career for the blind is discussed.

Wright, Richard B. "Laboratory Exercises for Visually Handicapped Botany Students." Journal of Visual Impairment and Blindness, Vol. 72, No. 10, p. 67, February, 1978.

This report is an account of the experiences that a college instructor had in teaching botany to a blind student. A multi-sensory, audio-tutorial approach is described which employed actual specimens, commercial and clay models. A technique for making raised line drawings with white glue is presented. The use of sighted assistants and recorded lectures is also suggested.

Zahl, Paul A. Blindness: Modern Approaches to the Unseen Environment. New York: Hafner Publishing Co., 601 p., 1962.

In this book a very diverse group of experts, brought together by invitation of the National Research Council under the auspices of the U.S. Veterans Administration, join in discussing the problem of adjustment of the blind to life in today's world of science and industry. Several sections of the book are devoted to the role of the blind in science and the applications of science and technology to the problems of blindness.

III. Sources Unavailable for Review

Copies of the following sources were locally unavailable for review. However, these titles are presented as potentially useful information.

Brett, James J. "Pathways for the Blind." Conservationist, pp. 13-16, June-July, 1971.

Brier, H. S. "Oscar, A Milliammeter for Sightless Amateurs." C.Q., July, 1948.

Evans, Q. "A Simple Capacitance Bridge." Braille Technical Press, Vol. 9, No. 11, November, 1958.

Information concerning issues of Braille Technical Press may be obtained from:

Library Services
New York Institute for the Blind
999 Pelham Parkway
Bronx, New York 10461

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